Statement of Work for CRPAQS Question 1 Task 1.3

Task 1.3. How adequate and valid are current methods for measuring meteorological variables at the surface and aloft? How well do the measurements provide needed spatial and temporal resolution required to meet the objectives of CRPAQS?

Discussion

The current methods can be categorized as existing wind speed and direction at the standard height of 10 meters, temperature and relative humidity typically at heights between 2-5 meters, and those measurements that have been added in the last 5 to 10 years that include remote sensing of winds and temperature using radar, RASS and sodar. ARB sponsored aircraft temperature soundings are made routinely as weather permits from Bakersfield, Fresno, and Sacramento. Added to these for the CRPAQS program were the special study sites operated for the duration of the program. This task will integrate some of the analyses performed as part of 3.3 and 7.1, as well as provide useful information to aid in analyses performed in those tasks. The tasks to be performed will include:

1. The database of measurements and audits of those measurements made during CRPAQS will be reviewed and summarized and the completeness and validity of the database assessed. The measurements will be divided into the following categories and the adequacy and validity of measurements summarized:

    1.1. Existing routine surface measurements made by federal, state and local agencies, including collection of vector and scalar wind quantities.

    1.2. Existing upper air measurements that have been added at agency operated sites within the last five years. These stations include Visalia, Sacramento, etc. These are the stations that will be operated on a continuing, routine basis.

    1.3. Surface and upper air stations added specifically for the CRPAQS program.

    1.4. Calculation algorithms used for key meteorological variables including a non-wind speed weighted wind direction (scalar wind direction) and the standard deviation of the wind direction. Uniformity in the algorithms is essential when dealing with the measurement of low wind speeds.

    1.5. Results will be summarized by measurement type to document the usability of the data.

2. Evaluate the surface mechanical sensor performance relative to the non-moving part sonic anemometers at the Angiola site. This is to determine if the existing network of surface sensors is adequate to evaluate the transport conditions under low wind speeds. Overall, how well the mechanical sensors

compare to the sonic sensors in conditions typical of the IOPs will be evaluated. Subtasks will include:

2.1. Data from the IOP periods will be obtained and time series plots will be developed comparing the different levels measured at the tower.

2.2. Key periods will be parsed from the database that includes the low wind speed events, and further analyses of the performance of the mechanical sensors will be conducted.

2.3. Results will be summarized identifying existing sensor performance and the value of those sensors in appropriately describing the low wind speed performance during the IOP conditions.

3. Evaluate the spatial representativeness of wind measurements made during the stagnation episodes. This will help determine whether the low wind speed measurements made at other sites are useable to describe transport. The two towers at the Angiola site will be used for the analysis and subtasks will include:

3.1. Comparison of speeds and directions from comparable levels of the 20 and 100 meter towers during the stagnation episodes. The initial analysis will be performed using time series plots.

3.2. Perform statistical comparability analyses of the selected data sets under the low wind speed events.

3.3. Results will be summarized that describe how representative measurements are under low wind speeds. It is anticipated that the results will be stratified by wind speed categories.

4. Assess the validity of the two-component sodar data collected during the stagnation periods. The sodars provided by NOAA/ETL did not have a vertical component, thus under low wind speed conditions any vertical motion will significantly alter the calculated horizontal winds. Since the intent of the sodars was to fill in the gap below the range gates of the radar wind profiler, and the wind profiler does incorporate the vertical velocity correction, it is essential to understand any limitations in the sodar data that are introduced by the lack of vertical wind measurement. The assessment will be performed using the sodar operated at the Angiola tower and will include the following tasks:

4.1. Determine appropriate data analysis periods, anticipated to be coincident with IOPs.

4.2. Evaluate the sodar measured winds against winds measured on the 100 meter tower. It is anticipated that winds measured by the sonic anemometer will be used for the analysis, but comparisons against the mechanical sensors are also anticipated. The sonic winds will be compared in anticipation of having a measure of vertical velocity to aid in the identification of periods of higher vertical motion.

4.3. Results will be summarized that describe any potential limitations in the use of the sodar data for wind analysis.

5. Assess the adequacy of the vertical coverage of the upper air measurements. For example, do the wind and temperature measurements made by the RASS adequately describe the behavior of the inversion that helps to drive the capping of the valley mixed layer. This task is tied into the analyses that will be performed in Task 3.3 to look at the adequacy of the measurements to describe the mixed layer depth. This analysis will include:

   5.1. Comparisons of the measured inversion behavior of the RASS at Angiola, supplemented by the temperature measurements made on the tower during specific stagnation events. These are the periods when the base of the inversion is the lowest and the potential for the RASS to miss this base is the highest.

   5.2. Determine the significance of the RASS to potentially miss the inversion base. Is it really that important, or is enough data available to understand the processes taking place.

   5.3. Determine if the radar wind profiler has the ability to see winds within shallow mixed layer during IOPs, and to what extent the minimum altitude seen by the radar limits the ability to document the transport winds in the mixed layer. This will be performed during the primary winter IOPs using data from the Angiola site where sodar winds, in addition to the tower winds, are available. Selected key stagnation periods will be analyzed for the ability of the radar winds to see down within the mixed layer.

   5.4. Results will be summarized that describe limitations on the use of the RASS data and what additional data is potentially needed to interpret the strength and position of the inversions.

6. Assess the impact of the RASS gate averaging on the calculated height and strength of inversions. The principal of operation of the RASS creates average bins, or gates in the RASS data that represent the average temperature throughout the gate depth. Given the extremely strong inversions present during fog episodes, the RASS data may tend to smooth the actual structure of the surface-boundary layers. While there is only limited data available with coincident measurements there is a possibility that adequate information may be available to assess the smoothing that may be performed. The analysis will include:

   6.1. Review available data for coincident rawinsonde and RASS measurements to determine candidate sites for comparison. Fresno and Bakersfield are candidate sites. Given the much large gate spacing at Fresno, a comparison to the RASS at Visalia may also be in order. Additionally, the initial audits of the RASS systems had coincident rawinsondes that could be used for comparisons.

6.2. Evaluate data sets to determine the potential uncertainty added to the inversion height determination by the RASS as a result of the gate averaging. Additionally, determine to what degree the inversion strength may be diminished as a result of the averaging.

6.3. Results will be summarized that quantify the effect that the RASS gate spacing may have on the inversion statistics.

7. In a similar manner as for RASS, assess the usefulness of the ARB sponsored aircraft temperature soundings. During the winter IOPs, rawinsonde observations were made in Fresno and Bakersfield at reasonably close distances to the airports where the aircraft soundings were taken. Aircraft operations may be curtailed due to low ceilings and/or visibilities that are characteristic of the periods of interest. The analysis will include:

7.1 Obtaining the available data for IOP's. Aircraft soundings are made at Bakersfield, Fresno, Sacramento and Red Bluff routinely, and at Columbia on a non-routine basis. Since rawinsondes were taken only at Fresno and Bakersfield, only those aircraft sounding data are required. T&B Systems made the rawinsonde measurements and those data are on-hand.

7.2 The magnitude, base and top of inversions as best described by the two methods will be compared to evaluate the uncertainty of using only the aircraft soundings.

7.3 Results will be summarized that quantify the error introduced in inversion characteristics due to the vertical resolution of aircraft soundings.

8. Assess the temporal adequacy of the measurements made in the surface data to determine if one hour or more frequent measurements are needed. The analysis will examine time series plots of the various time resolution data at the Angiola site during the IOPs and determine if the higher resolution data adds to the value of the data or would change any of the analyses performed. The analysis will include:

8.1 Selection of the appropriate IOP periods and data sets for analysis.

8.2 Time-series of high resolution particulate mass and chemistry will be merged with comparable time-resolved meteorological data. That data set will be examined for relationships between the observables. For example, wind shifts and/or humidity changes associated with significant changes in bsp suggest differing air mass histories.

8.3 The same meteorological data set processed as standard (i.e. hourly averaged) will be examined to determine if the relationships identified in subtask 8.3 hold.

9. Meetings and Reports

9.1 CRPAQS meetings will be attended as appropriate by Robert Baxter and/or Don Lehrman (in Sacramento).

9.2 Monthly progress reports will be prepared.

9.3 It is anticipated that the final report will consist of a journal article to be submitted for peer-reviewed publication accompanied by appendices that will not be submitted for publication. Because of the close interrelationship of this task to 3.3, this final report will be integrated into the results of the analyses in that task.

9.4 A paper describing the findings will be submitted to a technical conference. Similar to the journal article, these findings will be combined with those results obtained in Task 3.3.